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Subsurface architecture of a strike-slip collapse structure: insights from Ilopango caldera, El Salvador

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While most calderas are created by roof collapse along ring-like faults into an emptying magma reservoir during a large and violent explosive eruption, an additional condition for caldera formation may be tectonically induced extensional stresses. Here we provide geophysical insights into the shallow sub-volcanic plumbing system of a collapse caldera in a major strike-slip tectonic setting by inverting Bouguer gravity data from the Ilopango caldera in El Salvador. Despite a long history of catastrophic eruptions with the most recent in 500 A.D., the internal architecture of the caldera has not been investigated, although studies of the most recent eruption have not identified the ring faults commonly associated with caldera collapse. The gravity data show that low-density material aligned along the principal stress orientations of the El Salvador Fault Zone (ESFZ) forms a pronounced gravity low beneath the caldera. Extending to around 6 km depth, the low density structure likely maps a complex stacked shallow plumbing system composed of magmatic and fractured hydrothermal reservoirs. A substantial volume of the plumbing system must be composed of a vapour phase to explain the modeled negative density contrasts. We use these constraints to map the possible multi-phase parameter space contributing to the subsurface architecture of the caldera and propose that the local extension along the complex ESFZ controls accumulation, ascent and eruption of magma at Ilopango. The data further suggest that future eruptions at Ilopango could be facilitated by rapid rise of magma along conjugate fault damage zones through a mechanically weak crust under tension. This may explain the absence of clear ring fault structures at the caldera.